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SIG – The Role of Human-Computer Interaction in Next-Generation Control Rooms

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ABSTRACT
The purpose of this CHI Special Interest Group (SIG) is to facilitate the convergence between human-computer interaction (HCI) and control room design. HCI researchers and practitioners actively need to infuse state-of-the-art interface technology into control rooms to meet usability, safety, and regulatory requirements. This SIG outlines potential HCI contributions to instrumentation and control (I&C) and automation in control rooms as well as to general control room design.

Author Keywords
Control room, interface, safety, instrumentation and control, automation

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Control rooms are used to monitor and direct complex production and distribution activities, which are common to Supervisory Control and Data Acquisition (SCADA) systems. Control rooms are found in a diverse range of industries, ranging from manufacturing, petroleum distribution over pipelines, power generation, electrical distribution systems, to air traffic control. While the range of control room applications is diverse, there are underlying similarities across applications. These similarities include:

- The use of machine interfaces to simplify the display of complex system functioning
- The safety critical, potentially high consequence nature of the control task
- The central role of the control room operator as a system monitor
- The presence of legacy technologies
- The existence of regulatory measures to govern the control room procedures and interface technologies

These factors create a unique domain for the infusion of design ideas from the human-computer interaction (HCI) community. The challenge is to capitalize on lessons learned from other domains and apply them to control rooms. The experimental and consumer-level interfaces common in the HCI research literature largely have yet to be translated to useful interface solutions for the safety critical complex systems exemplified by control systems. Contemporary HCI has largely focused on making interfaces that are usable, appealing, and useful [1]. However, control rooms demand that interfaces are usable, safe, and regulatory-standards compliant. As industries move to adopt new technologies [3], it is crucial that HCI researchers and practitioners actively contribute to next-generation control room technologies.

PURPOSE OF SPECIAL INTEREST GROUP SESSION
The purpose of this special interest group (SIG) is twofold. First, it is the intention of the organizers to provide a forum in which the importance of HCI for control room design may be emphasized to the HCI community at CHI. Overview presentations will allow interested CHI conference attendees to gain insight into the status and issues of HCI in current control rooms, with examples drawn from control rooms in nuclear power plants and electrical grid management systems, two areas which are slated for significant upgrades in the next decade [2-3].

The purpose of this SIG is also to gather ideas to develop a path forward for the incorporation of current ideas from HCI into next-generation control rooms. Participants in the SIG will have the opportunity to contribute their ideas for interfaces that are not only usable but also safe and

regulatory-standards compliant. It is the intention of the organizers that interested CHI participants will have the opportunity to form a cross-disciplinary working group that will develop an interface technology roadmap for next-generation control rooms. Such a roadmap may serve as both a guideline for industries undertaking control room upgrades and also as an outline for research and design contributions from the HCI community.

SCHEDULE FOR SPECIAL INTEREST GROUP SESSION

The 90-minute SIG session will feature three segments as follows:

1. *Introduction* (20 minutes). This segment will feature introductions between the organizers and the SIG participants, followed by a series of brief presentations by the organizers on central HCI issues in control rooms.

2. *Topical Working Groups* (35 minutes). The organizers will host three concurrent topical working groups, in which participants will have the opportunity to contribute their HCI insights. The three working groups are:

Instrumentation and Control (I&C) in Control Rooms. Current research gaps in control room I&C include automated controls; wireless systems; cyber security; issues of robustness and dependability of hardware and software; and the integration of controls, diagnostics, and decision-making aids. In terms of HCI, it is important to consider these issues in the context of information display, such as what information is needed and how to inject external information into system operations.

Control Room Design. Current control rooms typically feature multiple operators and a control room supervisor around a horseshoe shaped control room with wall-mounted and console based I&C. New interface technology affords the opportunity for considerable variation on this basic control room layout, from the use of dynamic displays and soft controls to increased functionality in individual operator workstations. There is also the possibility of using a single control room for multiple systems. Safety implications must address whether multiple systems can be adequately controlled from one control room and what the required staffing levels should be. HCI considerations regarding control room design include: the use of the traditional horseshoe control room design; the level of functionality of individual operator workstations; the use of large, dynamic displays instead of fixed panels; alternate display methods for annunciator information; control room scalability (i.e., use of modular units to increase the number of systems controlled by a single control room); staffing level requirements for new control room designs; and reconfigurability of the control room (i.e., upgrades or use of the same control room for different types of systems).

Automation and System Intelligence in Control Rooms. Advances in autonomous system technology potentially will allow control rooms to operate with minimal direct human intervention. It is therefore important to determine what levels of automation the control room should support. Should we develop a control system that is fully automatic, should we continue to operate in essentially a fully manual mode, or should we instead opt for some combination of manual and autonomous operation? Manual and autonomous operation may be applied independently to different system functions, and it is important for research to establish the optimal level of automation for individual system functions as well as for the overall control system. Issues related to automation include: ways to keep operators vigilant and engaged in a monitoring role; benefits and risks of automated systems versus the human operator during all phases of operations; determination of what functions cannot be automated and why; integration of multiple autonomous systems; consequences of autonomous system failure; ways automation limits the human's ability to respond to an event; maintaining operator vigilance within an automated system; ways to ensure operator trust of the autonomous system; the effect of alarm management on the operator; task sharing between the operator and the system; verification of human performance in automated systems; and public and regulatory acceptance of different levels automation.

3. *Summary* (35 minutes). Each working group will present a ten-minute summary of the topical discussions. The organizers will then conclude the SIG session with final remarks and future plans for the working group.

CONCLUSION

As industries transition to next-generation control rooms, many new technologies are available to ensure efficient and safe operations. A key component of control room operations is the human operator, who must ultimately use the new technology. The purpose of this SIG is to highlight safety, performance, and regulatory issues associated with the adoption of new control room technology. These issues serve as the crucial starting point for HCI research in next-generation control room designs.

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3. US Department of Energy Nuclear Energy Research Advisory Committee and the Generation IV International Forum. *A Technology Roadmap for Generation IV Nuclear Energy Systems, GIF-002-00* (2002).